Research Summary

TMA Truck Safety


TMA Truck Safety
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PREPARED BY:
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Truck-Mounted Attenuators (TMAs) are critical for work zone safety. However, factors such as distracted and impaired drivers, speeding in work zones, traffic congestion, and increased road construction and maintenance activities have led to a rise in TMA-involved crashes.

The objective of this project is to evaluate the effectiveness of in-vehicle safety countermeasures aimed at enhancing driver protection in TMA trucks and provide data-driven recommendations to improve TMA truck safety. To accomplish this objective, the project includes a review of TMA-involved crash reports in Missouri, an assessment of current in-vehicle safety features, and a simulation study focused on three specific safety countermeasures: active headrest, reactive seatback, and anti-whiplash system.

A review of Missouri crash data indicates that rear-end collisions are the predominant type of TMA-involved crash, with head and neck whiplash injuries frequently affecting TMA drivers. This finding underscores the importance of countermeasures that target these specific injury mechanisms. The study also conducted a comprehensive review of TMA truck safety features. In collaboration with Missouri Department of Transportation (MoDOT) engineers, the project identified active headrests (20 mm/40 mm displacement), reactive seatbacks (20 degree/30-degree rotation), and anti-whiplash systems as priority countermeasures.

Active headrests are designed to automatically move forward during a rear-end collision. Reactive seatbacks are engineered to absorb and manage impact forces by reclining or shifting slightly backward upon impact. Anti-whiplash systems integrate the reactive seatback with a translational spring in the seat base, effectively absorbing energy and limiting excessive seatback rotation.

> *"This study highlights the importance of in-vehicle safety countermeasures for protecting TMA truck drivers."*

Biomechanical simulation modeling was used to evaluate the injury mitigation impact of selected safety countermeasures. As shown in Figure 1, a digital biomechanical model was created to simulate the effects of rear-end collisions on TMA drivers. Telematic data from MoDOT's fleet was integrated into the simulation, providing real-world data on impact accelerations and collision dynamics.

The simulation tests involved six collision scenarios, featuring vehicles ranging from 4,000 pounds sedans to 80,000 pounds semi-trucks, at both straight and 30-degree offset collision angles. Injury metrics such as Neck Injury Criterion (NIC), Normalized Neck Injury Criterion (N_{ij}), and Neck Protection Criterion (N_{km}) were used for a quantitative comparison.

1. Active Headrest: The active headrest consistently reduced injury criteria values across most scenarios. The 40 mm active headrest configuration was particularly effective in straight and angled collisions, demonstrating significant reductions in NIC, N_{ij}, and N_{km} values.

2. Reactive Seatback and Anti-Whiplash System: Results of the reactive seatback and anti-whiplash systems were mixed. While both countermeasures provided modest reductions in injury criteria for low-impact collision scenarios, their performance was less reliable in high-impact collision scenarios, particularly with heavy vehicles at 18g force levels.

3. Limitations in High-Impact Data: Simulations involving the heaviest vehicles (80,000-pound) may not fully reflect real-world conditions due to the limited availability of high-impact telematic data.

This study highlights the importance of in-vehicle safety countermeasures for protecting TMA truck drivers. The active headrest, especially at 40mm displacement, was considered as the most effective countermeasure. The reactive seatback and anti-whiplash system only demonstrated benefits in low-impact collisions. Future research could continue refining these systems to enhance their adaptability and reliability in high-impact scenarios.

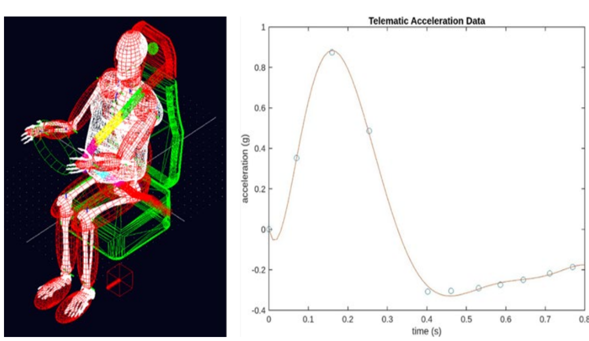

Figure 1: Digital biomechanical model and sample acceleration profile for a rear-end crash.

Project Information

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